Circle your lab day and time.

Your name:		Tue	Tue	Tue	Wed	Thu	Thu	Fri
TA name:		**10-12**	**12-2**	**2-4**	**12-2**	**10-12**	**12-2**	**12-2**

Lab 3: Electric Potentials

INTRODUCTION

Electric potentials are like the middle movies in trilogies: the middle movie makes no sense unless you've seen the first movie and provides the crucial setup for the third movie (although much of this setup can't be appreciated until you've seen the third movie – for instance, think about *Pirates of the Caribbean: Curse of the Black Pearl* or *Star Wars: The Empire Strikes Back*). To understand electric potentials, you definitely need to know about electric charges, forces, and fields; however, you won't really appreciate the significance of what electric potentials do until you study electric circuits. The goal in this lab is to explore electric potentials (surrounding a single point charge, multiple point charges, and non-point charges) and its relationships with electric fields and work.

The apparatus you will be using today is basically a translucent plastic bin that has been shallowly filled with tap water. A grid is attached to the bottom of the bin, so that when you look at the bin from the top, you have a way to identify locations in the bin. A metal ring sits inside the bin. Also available are two metal cylinders, some metal bars, a 6-Volt battery, a multimeter with probes, an extended LED, and wires with alligator clips. The directions in the following sections will guide you in how and when to use these materials.

PART I: SINGLE POINT CHARGE

A. Electric Potentials

- Sketch the location of the **metal ring** in the plastic bin in Figure 1 (page 5).
- Clip a wire from the negative terminal on the battery to the metal ring. Label the ring in Figure 1 with a negative sign.
- Place one of the metal cylinders somewhere inside (but not touching) the ring on the grid. Clip a wire from this cylinder to the positive terminal of the battery. Record the location of this cylinder with a plus sign inside a circle in Figure 1. This represents a single, point-like positive charge.
- Take the black probe from the multimeter and clip it the metal ring. At the same time, survey the space around the object with the red probe to find 5-8 points (or until you can see a pattern) on the grid where the *voltage* (or *electric potential*) reading is 4 V. Record each point you find into Figure 1 and connect these points to draw a line. Label this line 4 V.

  When the voltage is the same everywhere along a line, it is called an *equipotential line*. Equipotential lines are similar to contour lines on a topographical map (which connects points of the same elevation) and to isotherms on a weather lab (which connects points of the same temperature).

  Repeat this step to draw equipotential lines for 3 V and 2 V.

- Refer to the equipotential map you drew in Figure 1 to answer the following questions.
  – How did the voltage change as you moved further away from the metal cylinder?

– For each situation below, determine if the shape and voltage of the equipotential lines will change (when compared to Figure 1). Provide a brief explanation for your choices.

Situation	Will Shape Change? Why?	Will Voltage Change? Why?
wires to battery terminals are switched		
voltage of battery is doubled		

B. Relationships with Electric Fields and Work

- Sketch at least five electric field lines for the system in Figure 1. Keep in mind that the metal cylinder is positively charged and the metal ring is negatively charged. Are the electric field lines you drew perpendicular to your equipotential lines? (Hint: They should be.)

- Electrical potentials can be thought of as the work done per charge when a particle is displaced. Would a test charge in Figure 1 do more work when it is displaced along an equipotential line or an electric field line? Explain.

– You previously learned that work is related to energy. Place the probes of an LED (1) along an electric field line and (2) along an equipotential line. Which line caused the LED to light up?

– If the distance between the probes of an LED is increased along the line that caused the LED to light up, what happens to its brightness? Explain.

PART II: MULTIPLE POINT CHARGES

A. Electric Potentials

- Keep the metal cylinder hooked up to the positive terminal of the battery and re-copy its location into Figure 2 (page 5).
- Unclip the wire from the metal ring and remove the ring from the plastic bin. Clip this wire to the second metal cylinder and place this cylinder somewhere on the grid at least **20 cm away** from the first metal cylinder. Record the location of the second cylinder in Figure 2 with a minus sign inside a circle. This system represents multiple point-like charges.
- Clip the black probe from the multimeter **to the second metal cylinder**. Like before, survey the space around both metal cylinders in the bin with the red probe to find 5-8 points (or until you can see a pattern) on the grid where the voltage reading is 4 V. Record these points in Figure 2 and sketch the equipotential line. Make sure to label the equipotential line with the voltage reading. Repeat this step for 3 V and 2 V.

- Compare Figures 1 and 2. How did the addition of the second metal cylinder (charged oppositely from the first metal cylinder) affect the shape of the equipotential lines in Figure 1?

- Using the equipotential map you created in Figure 2, predict the voltage at the locations listed in the table below. Briefly explain your reasoning for each choice. Check your predictions with the multimeter.

Location	Predicted Voltage	Brief Explanation	Actual Voltage
(−)			
(+)			
B5			
K11			
R24			
W42			

- Using the actual voltage values from the previous table, calculate the electric potential difference between the locations listed below (also show your work). Afterwards, check your calculations with the multimeter.

Locations		Electric Potential Difference	
From	To	Calculated (show your work)	Actual
W42	(−)		
B5	(−)		
K11	R24		
R24	B5		

B. Relationships with Electric Fields and Work

- Sketch electric field lines for the system in Figure 2. (Again, make sure the electric field lines you draw are perpendicular to the equipotential lines.) Can it be generally said that if a charged object is free to move in an electric field, it will move from an area of higher voltage to an area of lower voltage? Explain.

- Using the equipotential map you created in Figure 2 and the LED, explore how you would place the probes of the LED to get the maximum brightness. Explain.

- Referring to Figure 2, describe and explain how the spacing between equipotential lines would affect the behavior of a positive test charge if it is released in a region where the equipotential lines are:
  - closely spaced
  - widely separated
- Describe and explain how a charge placed at K11 in Figure 2 would move if it was charged:
  - positively
  - negatively
- Now place the black probe from the multimeter directly halfway between the two metal cylinders. Using the red probe from the multimeter, survey the space around both metal cylinders.
  - What happens to the values of the equipotential lines when you approach (1) the positively charged cylinder and (2) the negatively charged cylinder? Explain.
  - Does the shape of the equipotential map differ from Figure 2? Explain.

PART III: NON-POINT CHARGES

- In the lab, there are various metal shapes. Select two different shapes (one shape can be the same from Part II). Replace the object(s) from Part II with your new shape(s). Record the locations and signs of both shapes in Figure 3 (last page). Use the multimeter to survey the space around the metal objects in the pan. Find and draw at least five equipotential lines in Figure 3.
- From the equipotential map you drew in Figure 3, what do you notice about the shape of the objects compared to the shape of the equipotential lines when the equipotential lines are:
  - close to an object
  - further away from both objects
- Using the equipotential map you created in Figure 3 and the LED, explore where you would place the probes of the LED to get the maximum brightness *and* the shortest distance between the LED probes. Explain.

Figure 1: Equipotential Map of Non-Point Charges

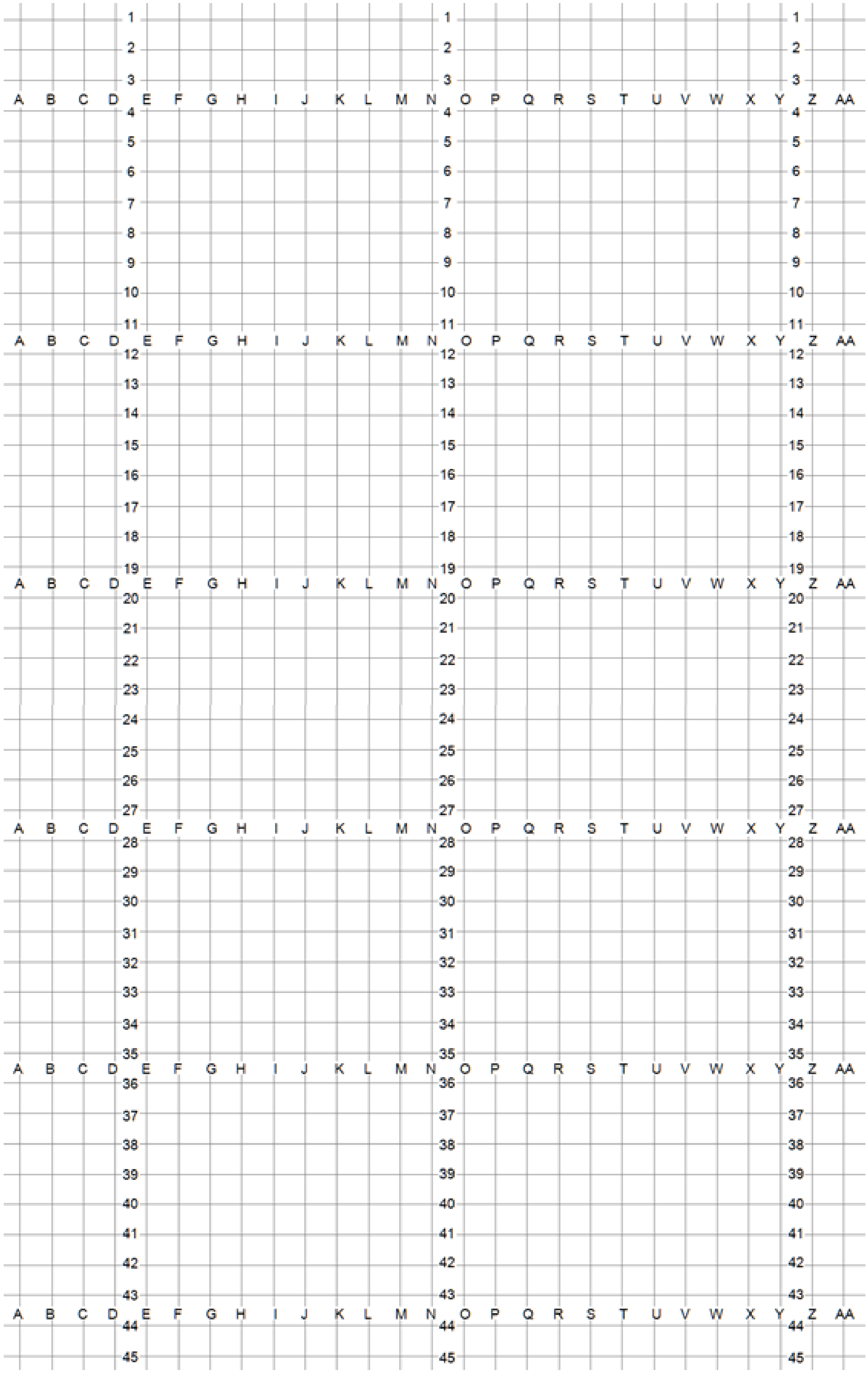

Figure 2: Equipotential Map of Non-Point Charges

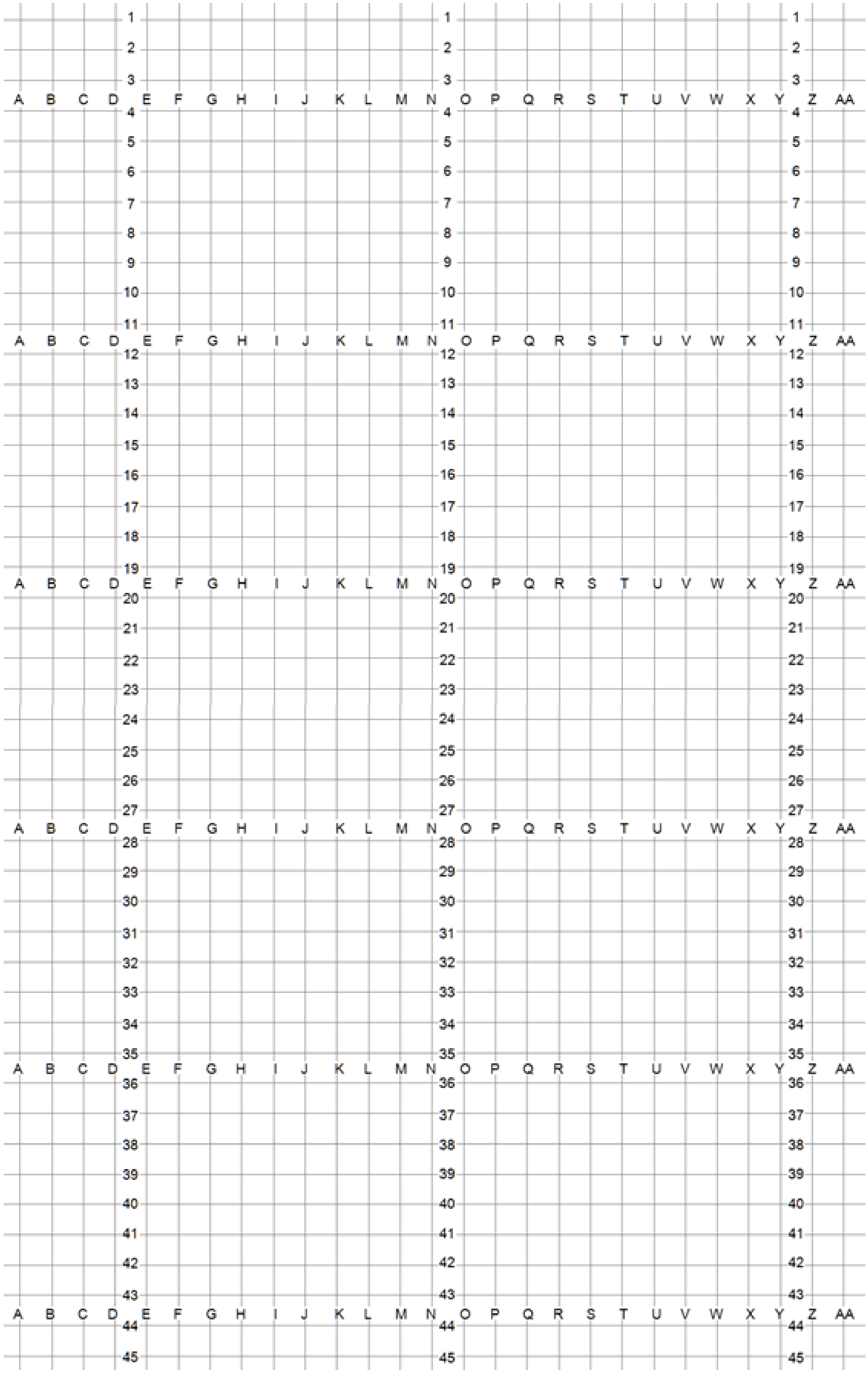

Figure 3: Equipotential Map of Non-Point Charges